3.12 EXISTING LIGHT WATER REACTOR SITE (GENERIC)

Currently in operation are 110 commercial nuclear power reactors located at 72 sites in 32 of the contiguous United States. Of these, 58 sites are located east of the Mississippi River. Most of this nuclear capacity is located in the Northeast (New England States, New York, and Pennsylvania), the Midwest (Illinois, Michigan, and Wisconsin), and the Southeast (the Carolinas, Georgia, Florida, and Alabama). No commercial nuclear power plants are located in Alaska or Hawaii. Approximately half of these 72 sites contain 2 or 3 nuclear units per site. Typically, nuclear power plant sites are located on, and are situated near, flat-to-rolling countryside in wooded or agricultural areas. More than 50 percent of the sites have 80 km (50 mi) population densities of less than 77 persons per km^2 (200 persons per mi^2), and over 80 percent have 80 km (50 mi) densities of less than 193 persons per km^2 (500 persons per mi^2). Site areas range from 34 to 12,000 ha (84 to 30,000 acres). Almost 60 percent of the plant sites encompass 200 to 800 ha (500 to 2,000 acres). Larger land-use areas associated with plant cooling systems include reservoirs, artificial lakes, and buffer areas. Because it is beyond the scope of this PEIS to analyze all of them, the environmental baseline for the existing LWR was developed as a generic environmental site description that is representative of an existing reactor site located somewhere in the contiguous United States.

A sample of reactors from across the United States was compiled in order to generate generic operating characteristics for a commercial LWR, since no specific site or reactor has been selected. The sample was studied in detail to determine valid, applicable characteristics that could be used to describe a generic reactor using MOX fuel. The sample sites would not be an exhaustive list of potential sites but are used to define the generic affected operational and environmental characteristics. The sample includes eight operating high power (greater than 1,200 MWe) PWRs and four BWRs built after 1975. Characteristics of these 12 were felt to be representative of both reactor types, since none of the 12 experienced any unusual operating conditions over the operating period reviewed. Where possible, data was averaged for the 5-year period to smooth out unusually low or high values due to shutdowns for reasons other than normal refueling or maintenance activities.

Data for each reactor characteristic were taken from calendar years 1988 to 1992 (ORNL 1995b:A-5). Entries for all 12 plants were used to determine an average for each operational characteristic (for example, waste generated).

For determining the environmental setting (for example, land area) of the generic reactor site, a second set of 10 reactors at 5 existing commercial reactor sites located across the United States were selected. These sites were as follows:

- Byron #1 and #2, IL
- Catawba #1 and #2, SC
- LaSalle #1 and #2, IL
- Palo Verde #1, #2, and #3, AZ
- WNP #2, WA

3.12.1 LAND RESOURCES

The approach to defining the environmental setting for land resources is not site specific. Consequently, a range of land use and visual resources conditions for a generic existing LWR site has been provided (see Table 3.12.1–1).

Table 3.12.1–1. Land Resources Attributes of the Generic Existing Light Water Reactor Site

Land Use Attributes	
Land Area	419 ha to 1,640 ha[a]
Land Ownership	Public or private
Percent of Site Area Developed	
With cooling towers	3 to 9 percent
With cooling lakes	67 to 76 percent
Existing Land Use	
Onsite	Industrial; Undeveloped
Offsite	Forest land; Agriculture; Residential; Commercial; and/or Industrial
Land Use Compatibility	Likely
Plans, Policies, and Controls	
Jurisdiction	DOE; Other Federal; State; local
Enforcement	Lax to stringent
Conformance	Likely
Visual Resource Attributes	
Landscape Character	
Site	Flat to gently rolling topography; adjacent to large water body
Viewshed	Small to medium size urbanized area; surrounding agriculture; and/ or forest
Visual Resource	
Sensitivity level	Low to medium to high
Distance zones	Foreground, middleground, background, and seldom-seen
BLM VRM class	5 (developed area)
Degree of contrast	NA (existing)

[a] Land area already dedicated.
Note: NA=not applicable.
Source: NRC 1982b.

Land Use. The land area requirement for a generic existing LWR site could range from 419 to 1,640 ha (1,035 to 4,050 acres). However, this land area has already been dedicated; additional land area is not required. Plant facilities would probably be sited on 3 to 9 percent of the total site area. For sites that utilize cooling ponds instead of cooling towers, facilities could occupy a larger percentage of total site area (67 to 76 percent). The site could contain multiple (ranging from one to three) nuclear units. The area of the site not utilized for facilities and activities would be left undeveloped, and the range of land uses would likely be forested land, open space, or reserve/refuge.

The location of a generic existing LWR site would range between 3 to 55 km (2 to 34 mi) from the nearest city. The site would likely be further from the closest metropolitan area, up to 80 km (50 mi) distant. The site would be located adjacent to a large water body, such as a lake or river. Land use in the site vicinity could range from agricultural or forest uses to developed land uses such as residential, commercial, or industrial. The nearest residence to a generic existing LWR site would range from 1 to 6.5 km (0.6 to 4 mi) distant.

As this is an existing condition, site development would be in conformance with land-use plans, policies, and controls. Likewise, land-use incompatibility would not be an issue.

Visual Resources. The visual environment of a generic existing LWR site would likely be characterized by flat to gently rolling topography adjacent to a large water body. The site would be a developed area that contains facilities and activities, encompassed by an undeveloped buffer area. The viewshed would likely include a small- to medium-sized urbanized area with surrounding forest and agricultural use. Depending on topography, atmospheric conditions, vegetation, and distance, the facilities of a generic existing LWR site could be visible from adjacent viewpoints. Stack plumes from cooling towers could be visible under most meteorological conditions. Median visible plume lengths would usually range from less than 500 m (1,640 ft) in summer to 1000 m (3,280 ft) in winter (NRC 1981a:5-6,5-7). The facilities would be brightly lit at night. The range of public viewpoints could include public access roadways, urbanized areas, and recreation/scenic areas with high user volumes. The full range of sensitivity levels, and distance zones would occur (see Section 3.1.1 for discussion of visual resource inventory). Since the site would be adjacent to a large water body, it would be likely that distance zones would range from foreground to middleground. The developed areas of a generic existing LWR site would likely be consistent with a BLM VRM classification Class 5.

3.12.2 SITE INFRASTRUCTURE

Baseline Characteristics. Extensive infrastructures exist to support individual reactor sites as shown by the range of values displayed in Table 3.12.2–1. Approximately one-half of the 72 reactor sites in the United States contain two or three nuclear units. Larger land-use areas associated with plant cooling systems include reservoirs, artificial lakes, and buffer areas. Road infrastructure is needed for personnel access and intersite transportation requirements. Railroad infrastructure is required to support shipments of fuels, spent fuels, and outsized structural components among other items. Some sites are situated on navigable waters.

The reactor sites are located in a regional electric power pool made up of its parent utilities and a number of subregions. These power pools draw their electrical power from a variety of generating sources, as shown in Table 3.12.2–2.

Table 3.12.2–1. Generic Existing Light Water Reactor Site Baseline Characteristics

Characteristics	Site Availability
Transportation	
Roads (km)	5 to 20
Railroads (km)	0 to 12
Electrical	
Energy consumption (MWh /yr)	700,000 to 1,100,000
Peak load (MWe)	96 to 140
Fuel	
Oil (l/yr)	approximately 757,000

Source: ORNL 1995b.

Table 3.12.2–2. Generic Existing Light Water Reactor Site Regional Power Pool Electrical Summary

Characteristics	Energy Production
Type Fuel[a]	
Coal	14 to 59%
Nuclear	0 to 39%
Hydro/geothermal	2 to 46%
Oil/gas	<1 to 32%
Other[b]	0 to 30%
Total Annual Production	107,607,000 to 272,155,000 MWh
Total Annual Load	104,621,000 to 293,262,000 MWh
Energy Exported Annually	-45,400,000 to 6,359,000 MWh
Generating Capacity	24,870 to 61,932 MWe
Peak Demand	20,578 to 57,028 MWe
Capacity Margin[c]	4,064 to 13,655 MWe

[a] Does not total 100 percent due to range at power pools used to estimate the generic site.
[b] Includes power from both utility and nonutility sources.
[c] Capacity margin is the amount of generating capacity available to provide for scheduled maintenance, emergency outages, system operating requirements, and unforeseen electrical demand.
Source: NERC 1993a.

3.12.3 AIR QUALITY AND NOISE

Meteorology and Climatology. The meteorological and climatological conditions at the representative existing LWR sites in the United States include a wide range of extremes in ambient temperature, wind speed and direction, and precipitation. Therefore, no further description of meteorology and climatology has been provided with respect to a generic site.

Ambient Air Quality. Ambient air quality conditions at the representative existing LWR sites in the United States include a wide range of pollutants and conditions. Table 3.12.3–1 presents the baseline ambient air concentrations for criteria pollutants at a representative existing LWR site. As show in this table, the existing LWR site is expected to comply with the ambient air quality standards. Some of the existing LWR sites evaluated are located near or within nonattainment areas for PM_{10}, O_3, and CO.

Table 3.12.3–1. Comparison of Baseline Ambient Air Concentrations With Most Stringent Applicable Regulations or Guidelines at the Generic Existing Light Water Reactor Site

Pollutant	Averaging Time	Most Stringent Regulation or Guideline[a] (μg/m^3)	Baseline Concentration (μg/m^3)
Criteria Pollutants			
Carbon monoxide	8-hour	10,000	<0.01
	1-hour	40,000	<0.01
Lead	Calendar Quarter	1.5	[b]
Nitrogen dioxide	Annual	100	0.05
Ozone	1-hour	235	[c]
Particulate matter less than or equal to 10 microns in diameter	Annual	50	<0.01
	24-hour	150	0.015
Sulfur dioxide	Annual	80	0.04
	24-hour	365	0.15
	3-hour	1,300	0.35
Hazardous and Other Toxic Compounds			
No sources indicated			

[a] The Federal standards are presented.

[b] No sources indicated.

[c] Ozone, as a criteria pollutant, is not directly emitted nor monitored by the sites. See Section 4.1.3 for a discussion of ozone-related issues.

Source: 40 CFR 50; TVA 1974b.

Noise. Specific existing noise sources and characteristics of a generic existing LWR site cannot be described. However, it is expected that the area near such a site would be essentially rural in character and would have typically low background sound levels. Typical DNL in the range 35 to 50 dBA can be expected for such a rural location (EPA 1974a:B-4) where noise sources may include wind, insect activity, aircraft, and agricultural activity. Existing industrial noise sources and traffic noise at the site would result in higher background noise levels near the site and along site access routes.

3.12.4 WATER RESOURCES

Surface Water. Major surface water features in the generic existing LWR site area could range from a large navigable river to a large lake. The average flow rate of these water bodies could range from 28 to 3,360 m^3/s (989 to 118,658 ft^3/s). Other surface water features could include large ponds and/or small streams bordering the site.

Stormwater control retention/drainage ponds could be present at the site. These ponds would probably discharge to the nearest large surface water body.

Surface Water Quality. In the vicinity of the generic existing LWR site, the surface water bodies could range from being unclassified to classified as fresh water suitable for public and food processing water supply. The range of concentrations of typical surface water quality parameters that could be encountered at generic sites was presented in Table 3.10.4–1. High nutrient loads, low dissolved oxygen, and moderately high bacteria count could be encountered in the nearby large surface water body.

The generic existing LWR site would have an NPDES permit(s) that would dictate the acceptable levels of specific parameters in the liquid effluents that would be discharged to a nearby surface water body.

Surface Water Rights and Permits. Surface water rights concerning the large water body near the existing LWR site would involve non-impairment of designated uses.

Groundwater. The near-surface aquifer beneath the generic existing LWR site would occur under unconfined conditions and could range in average thickness from approximately 5 to 55 m (16 to 180 ft). Depth to groundwater could range from near the ground surface to 12 m (39 ft). The aquifer material could range from glacial drift to saprolite. In general, the generic existing LWR site would obtain groundwater from a confined aquifer underlying the near-surface aquifer. The confined aquifer would have an abundant supply of groundwater, although groundwater levels could be declining in the area. Water quality could range from good to fair.

Recharge to the near-surface aquifer would be primarily from rainfall and would occur in areas located from near the site to more than 16 km (10 mi) away from the site. Groundwater flow would typically be from these recharge areas towards the major surface water feature.

In areas surrounding the typical generic existing LWR site, groundwater would be used for domestic, industrial, agricultural, and municipal supply purposes. The classification of the aquifer beneath the site would be a Class II aquifer (that is, currently being used or a potential source of drinking water).

Groundwater Quality. Groundwater quality of the near-surface aquifer in the site area would range from good to fair. The range of hydraulic characteristics of the groundwater that might be encountered is presented in Table 3.10.4–2.

Groundwater Availability, Use, and Rights. Groundwater rights concerning the aquifer(s) near the generic existing LWR site could range from having potential for local restrictions on pumping to a reasonable use doctrine concerning neighboring landowners water availability.

3.12.5 GEOLOGY AND SOILS

Geology. The physiography of an existing LWR site could range from a flat nearly featureless plain to a highly dissected plain of arid to humid environments. The geology could range from alluvium to thick sequences of unconsolidated marine sediments, glaciofluvial material, and crystalline and sedimentary bedrock. These materials could range in age from Cenozoic to Precambrian (recent to over 600 million years).

The existing LWR sites could be located in Seismic Zones 0 to 2, which suggests there could be no to moderate levels of damage in the event of an earthquake (Figure 3.2.5–1). The geologic settings for Seismic Zones 0 to 2 considered for the existing LWR sites have histories of seismic activity that range from low to high. The location of the nearest capable fault could range from within the site boundaries to 350 km (217 mi) away from existing LWR sites. The nearest known epicenter of a damaging earthquake (MMI of VII or greater [Table 3.2.5–1]) could be approximately 350 km (217 mi) from existing LWR sites.

The existing LWR sites are not located within a region of active volcanism; however, an existing LWR site could be located within 164 km (102 mi) of a volcano.

Soils. The existing LWR sites could be located where the predominant soil types are loamy clays to gravel silty loams. These soils range from moderate to well drained soils. The erosion potential could range from minor to severe in those areas with slopes greater than 25 percent and which have been eroded in the past. The soils shrink-swell potential could range from low to severe, which is acceptable for standard construction techniques, depending upon the engineering controls employed. Wind erosion potential ranges from minor to severe.

3.12.6 BIOLOGICAL RESOURCES

Generic existing LWR sites are located within a number of the principal vegetation types. Vegetation types characteristic of the representative generic existing LWR sites used for this analysis include deciduous forest, grassland, desert, and southeast evergreen forest. Biological resources found within these vegetation types are described in Section 3.10.6 and 3.11.6. At a given site, biological resources could vary from those typically associated with the principal vegetation type of the area due to a variety of factors, including previous disturbance by man.

3.12.7 CULTURAL AND PALEONTOLOGICAL RESOURCES

Prehistoric Resources. Prehistoric resources in the vicinity of the existing LWR site may include sites, districts, or isolated artifacts. Archaeological sites may represent occupation during the Archaic through later prehistoric periods and can include hunting and butchering sites, cemeteries, campsites, and tool manufacturing areas. They may yield artifacts such as stone tools and associated manufacturing debris, and ceramic potsherds. Some sites may have been determined eligible for inclusion on the NRHP by the SHPO. Prehistoric resources are most likely to be affected by ground disturbance. No impacts to prehistoric resources are anticipated because this alternative does not involve new facility construction.

Historic Resources. Historic resources may include cemeteries, remains of commercial or residential structures, or standing structures. Some sites may be eligible for inclusion on the NRHP.

Native American Resources. To date, no Native American resources have been identified at the generic existing LWR site, but they may exist. Such resources can include cemeteries, geological or geographic elements (such as mountains or creeks), certain species of animals or plants, architectural structures (such as pueblos), battlefields, or trails. Such resources are objects or areas that are important to Native American groups for religious or historical reasons. There also may be visual impacts to Native American resources.

Paleontological Resources. To date, no paleontological resources have been identified at the generic existing LWR site. However, some fossil-bearing strata may exist that contain rare fossils or fossil assemblages.

3.12.8 SOCIOECONOMICS

The generic existing LWR site could potentially affect the socioeconomic environment of a given REA or ROI. The characteristics of the REA, ROI, and community are dependent upon geographic location. For employment and income, the economic area would be based upon industry interaction and linkages in the region. The anticipated residential distribution of project-related employees and their families would determine the ROI. This ROI would contain all principal jurisdictions and school districts likely to be affected by the proposed activity.

Because specific commercial LWR sites have not been proposed for burning MOX fuel, representative sites have been used to describe the affected environment. Five existing reactors encompassing four location types were used as representative sites to develop a range of conditions for discussion in this section. The first two communities, Sites A and B, are small communities tied to large metropolitan areas. Site C is a medium-size community near a large metropolitan area. The fourth site, Site D, is a medium-size community located in an urbanized area.

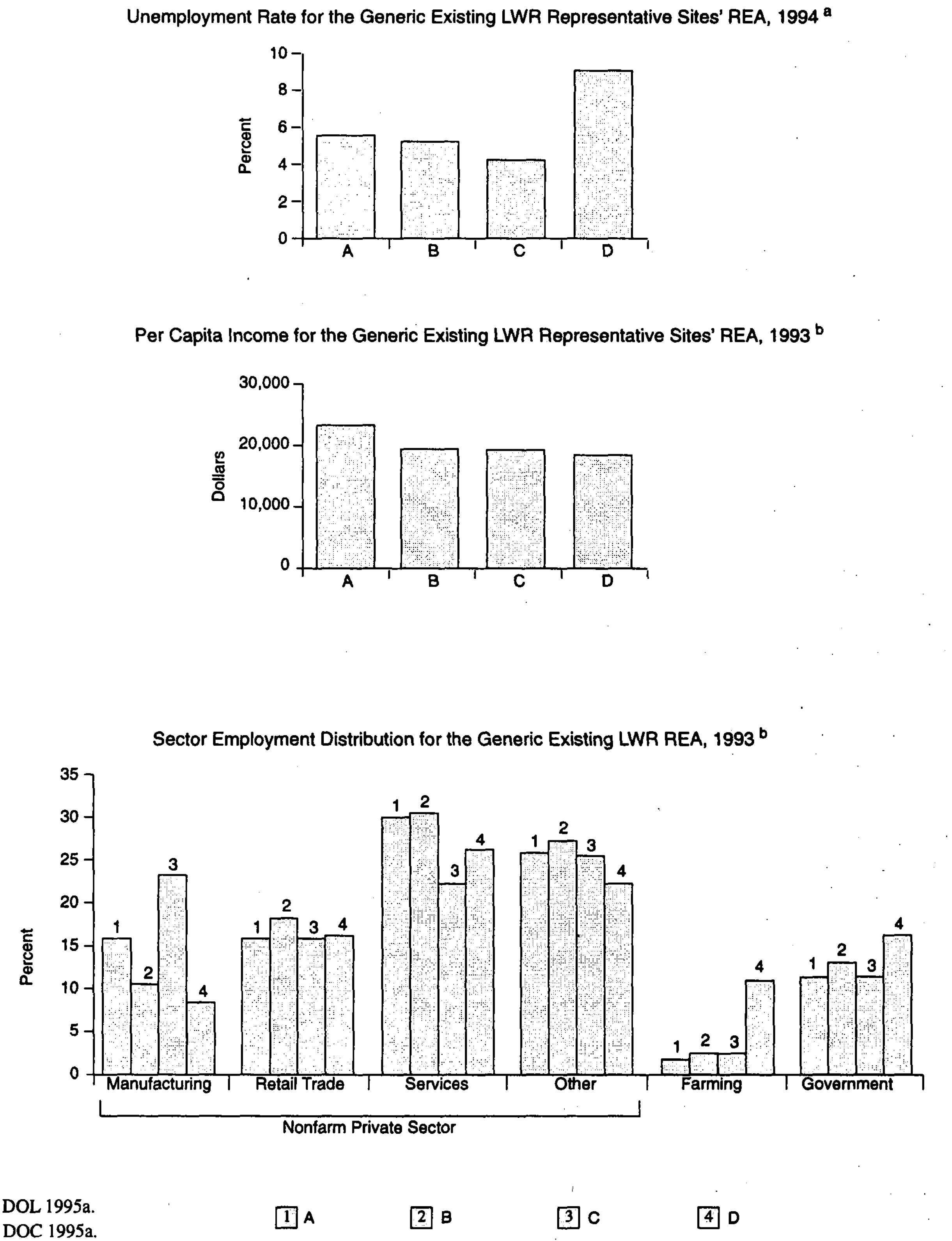
Small communities were characterized in Section 3.11.8. Medium-size communities and the vulnerability or susceptibility of a local community to changes in the economic base were described in Section 3.10.8. However, the specific communities discussed in this section are different from those discussed in Section 3.11.8.

Socioeconomic characteristics described for the generic existing LWR site include employment and local economy, population and housing, and local transportation. Site A, which had a 1992 population of 2,604, was located about 160 km (100 mi) from a large metropolitan area. Site B, with a 1992 population of 5,236, was located approximately 8 km (5 mi) from a small community and approximately 64 km (40 mi) from a large metropolitan area. Site C, with a 1992 population of 44,384, was located approximately 16 km (10 mi) from a medium-size community and approximately 48 km (29.8 mi) from a large metropolitan area. Site D, a medium-size community, had a 1992 population of 34,201 and a total urban population of more than 100,000. Statistics for employment and local economy were based on the REA for each site. Statistics for the remaining socioeconomic characteristics were based on the sites' ROIs.

Regional Economy Characteristics. Employment and regional economy statistics for each representative site's REA are discussed in this section and displayed in Figure 3.12.8–1. Between 1980 and 1990, the civilian labor force in the REA encompassing Site A increased 7.7 percent to the 1990 level of 4,811,800, and for Site B increased 49.6 percent to the 1990 level of 1,162,300. The civilian labor force for Site C, located near a large metropolitan area, increased 21.9 percent to the 1990 level of 862,500. The civilian labor force for Site D, located in an urbanized area, increased 9.9 percent to 254,800 persons. The 1994 unemployment rates in the two small communities' (A and B) REAs were 5.6 percent and 5.2 percent, respectively. Sites C and D had unemployment of 4.3 percent and 9.1 percent, respectively. The 1993 per capita incomes were $23,634 at Site A and $19,497 at Site B. Sites C and D had per capita incomes of $19,489 and $18,501, respectively.

Figure 3.12.8–1 displays the division of employment involving farming, nonfarming, and government sectors for each typical site. For the two small representative communities, the portions of total employment involving farming in the REAs were about 1 percent. Governmental activities for Sites A and B represented about 12 percent and 14 percent, respectively. Manufacturing was 16 percent of the total employment for site A and 10 percent for site B. Retail trade accounted for 16 percent and 18 percent of the total sector employment for Sites A and B, respectively. Service activities represented a 30-percent share of the total employment for Sites A and B.

For Sites C and D, the portion of total employment was about 1 percent and 12 percent for farming and 11 and 15 percent for governmental activities, respectively. The nonfarm private sector activities of retail trade and services were 16 and 22 percent of total employment, respectively, for Site C and 16 and 26 percent,



[a] DOL 1995a.
[b] DOC 1995a.

Figure 3.12.8–1. Employment and Local Economy for the Generic Existing Light Water Reactor Representative Sites' Regional Economic Area.

respectively, for Site D. Employments for manufacturing were 23 and 8 percent of total employment for Sites C and D, respectively.

Population and Housing. Population and housing trends in the representative ROIs are presented in Figure 3.12.8–2. The ROI population increase for the two small communities, A and B, between 1980 and 1994 were 6.4 (average annual increase of 0.5 percent) and 54.6 (average annual increase of 3.9 percent) percent, respectively. The number of housing units in the ROI increased 8.9 percent for Site A and 55.8 percent for Site B between 1980 and 1990. The 1990 ROI homeowner vacancy rates were 1.1 and 3.9 percent, while the renter vacancy rates were 5.9 and 16.4 percent for Sites A and B, respectively.

The ROIs surrounding Sites C and D experienced an 31.8-percent (average annual increase of 2.3 percent) and 19.8-percent (average annual increase of 1.4 percent) increase in population, between 1980 and 1994, and a 32.7- and 5.4-percent increase, respectively, in the number of housing units between 1980 and 1990. The 1990 homeowner and renter vacancy rates were 2.0 and 8.9 percent for Site C and 1.3 and 5.6 percent for Site D.

Community Services and Local Transportation. These characteristics are dependent upon a geographic location. The ROI would determine all principal jurisdictions and school districts likely to be affected by the proposed activity. Local transportation would be the existing principal road, air, and rail networks required to support the project activities.

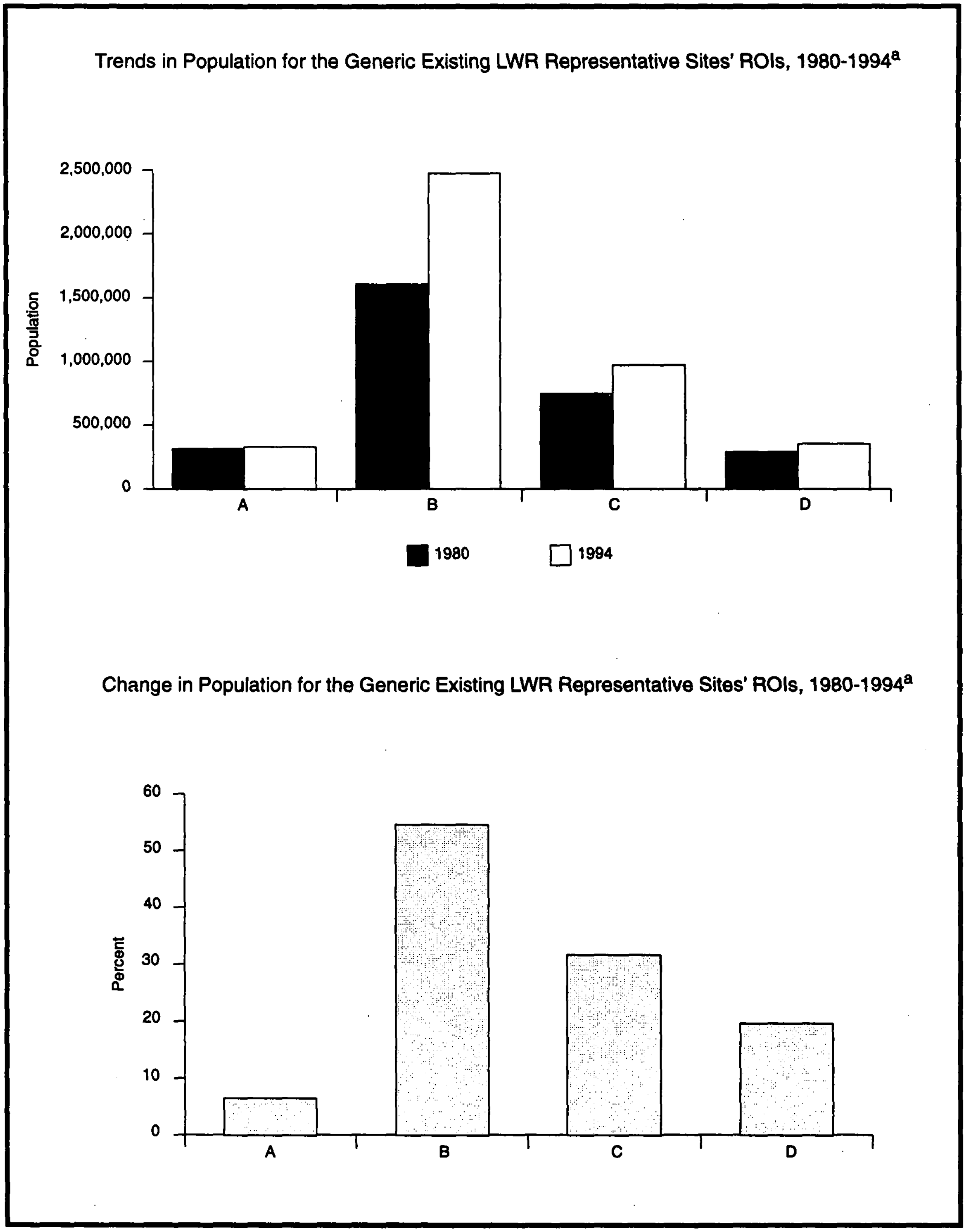
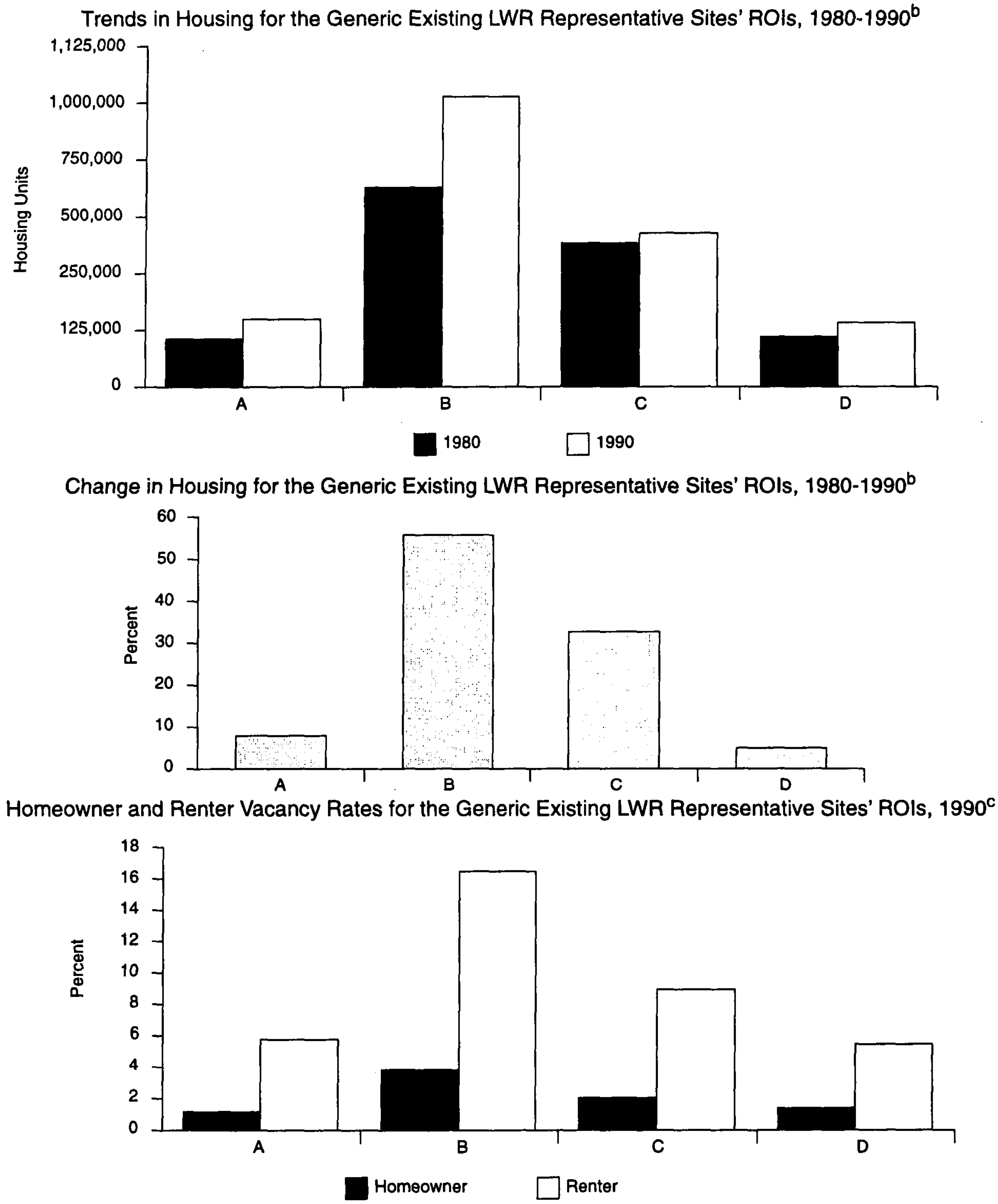


Figure 3.12.8–2. Population and Housing for the Generic Existing Light Water Reactor Representative Sites' Region of Influence.



[a] Census 1983b; Census 1983f; Census 1983k; Census 1983m; Census 1995a.
[b] Census 1982c; Census 1982e; Census 1982m; Census 1982r; Census 1991b; Census 1991d; Census 1991q; Census 1991r.
[c] Census 1991b; Census 1991c; Census 1991d; Census 1991q.

Figure 3.12.8–2. Population and Housing for the Generic Existing Light Water Reactor Representative Sites' Region of Influence—Continued.

3.12.9 PUBLIC AND OCCUPATIONAL HEALTH AND SAFETY

Radiation Environment. Major sources and levels of background radiation exposure to individuals in the vicinity of the generic existing LWR site are shown on Table 3.12.9–1. Annual background radiation doses to individuals are expected to remain constant over time. The total dose to the population size changes as the population size changes. Background radiation doses are unrelated to LWR site operations.

Table 3.12.9–1. Sources of Radiation Exposure to Individuals in the Vicinity, Unrelated to Operation at the Generic Existing Light Water Reactor Site

Source	Effective Dose Equivalent (mrem/yr)
Natural Background Radiation	
Cosmic radiation[a]	27 to 29
Cosmogenic radiation[b]	1
External terrestrial radiation[a]	29 to 30
Internal terrestrial radiation[b]	39
Radon in homes (inhaled)[b]	200
Other Background Radiation[b]	
Diagnostic x rays and nuclear medicine	53
Weapons test fallout	<1
Air travel	1
Consumer and industrial products	10
Total	361 to 364

[a] Based on information given in EPA 1981b.
[b] NCRP 1987a.
Note: Value for radon is an average for the United States.

Releases of radionuclides to the environment from generic existing LWR site operations provide another source of radiation exposure to individuals in the vicinity of generic existing LWR sites. Types and quantities of radionuclides released from generic existing LWR site operations in 1994 are listed in the 1994 radiological effluent release reports for the reference sites. The doses to the public resulting from these releases are presented in Table 3.12.9–2. These doses fall within radiological guidelines and limits (10 CFR 50, Appendix I and 40 CFR 190) and are small in comparison to background radiation.

Based on a risk estimator of 500 cancer deaths per 1 million person-rem to the public (Section M.2.1.2), the fatal cancer risk to the maximally exposed member of the public due to radiological releases from operations at the generic existing LWR site in 1994 is estimated to range from 3.9×10^{-9} to 7.0×10^{-7}. That is, the estimated probability of this person dying of cancer at some point in the future from radiation exposure associated with 1 year of LWR site operations ranges from about 4 in 1 billion to 7 in 10 million. (Note that it takes several to many years from the time of exposure to radiation for a cancer to manifest itself.)

Based on the same risk estimator, a range of 1.0×10^{-5} to 6.7×10^{-3} excess fatal cancers is projected in the population living within 80 km (50 mi) of the generic existing LWR site from normal operations in 1994. To place these numbers into perspective, they can be compared with the numbers of fatal cancers expected in these populations from all causes. The 1990 mortality rate associated with cancer for the entire U.S. population was 0.2 percent per year (Almanac 1993a: 839). Based on this mortality rate, the number of fatal cancers expected during 1994 from all causes in the population living within 80 km (50 mi) of the generic existing LWR site

Table 3.12.9–2. Radiation Doses to the Public From Normal Operation at the Generic Existing Light Water Reactor Site in 1994 (Committed Effective Dose Equivalent)

Members of the General Public	Atmospheric Releases		Liquid Releases		Total	
	Standard[a]	**Actual**	**Standard**[a]	**Actual**	**Standard**[a]	**Actual**[b]
Maximally exposed individual (mrem)	5	$1.3x10^{-3}$ to 1.10	3 per reactor	0 to 0.29	25	$7.8x10^{-3}$ to 1.39
Population within 80 km[c] (person-rem)	None	0.016 to 13.3	None	0 to 1.28	None	0.020 to 13.3
Average individual within 80 km (mrem)[d]	None	$6.3x10^{-5}$ to $6.8x10^{-3}$	None	0 to $8.9x10^{-4}$	None	$7.9x10^{-5}$ to $6.8x10^{-3}$

[a] The standards for individuals are given in 10 CFR 50 Appendix I and 40 CFR 190. As discussed in Appendix I of 10 CFR 50, the 5 mrem/yr value is an airborne emission guideline and the 3 mrem/yr per reactor value is a liquid release guideline. Meeting these guideline values serves as a numerical demonstration that doses are as low as is reasonably achievable. The total dose of 25 mrem/yr is the limit from all pathways combined as given in 40 CFR 190.

[b] Totals cannot be obtained by summing the atmospheric and liquid release components since these component entries can be for different reactor sites.

[c] This population ranges from 252,000 to 1,960,000.

[d] Obtained by dividing the population dose by the number of people living within 80 km of the site.

Source: HNUS 1996a.

ranged from 505 to 3,920. These numbers of expected fatal cancers are much higher than the estimated range of $1.0x10^{-5}$ to $6.7x10^{-3}$ fatal cancers that could result from operations at the generic existing LWR site in 1994.

At the generic existing LWR site, workers receive the same dose as the general public from background radiation but also receive an additional dose from working at the site. Table 3.12.9–3 presents the range of the average worker, maximally exposed worker, and total worker dose from operations at the generic existing LWR site in 1993. These doses fall within radiological regulatory limits (10 CFR 20). Based on a risk estimator of 400 fatal cancers per 1 million person-rem among workers (Section M.2.1.2), the number of excess fatal cancers to generic existing LWR site workers from operations in 1993 is estimated to range from 0.16 to 0.34.

A more detailed presentation of the radiation environment, including background exposures and radiological releases and doses, is presented in the reference sites' environmental reports and environmental monitoring reports. The concentrations of radioactivity in various environmental media (including air, water, and soil) in the regions of the generic existing LWR site (onsite and offsite) are also presented in those documents.

Chemical Environment. The background chemical environment important to human health consists of the atmosphere, which may contain hazardous chemicals that can be inhaled; drinking water, which may contain hazardous chemicals that can be ingested; and other environmental media with which people may come in contact (for example, surface waters during swimming and soil through direct contact or via the food pathway). The baseline data for assessing potential health impacts from the chemical environment are those presented in Section 3.12.3.

Effective administrative and design controls that decrease hazardous chemical releases to the environment and help achieve compliance with permit requirements (for example, air emissions and NPDES permit requirements) contribute toward minimizing potential health impacts to the public. The effectiveness of these controls is verified through the use of monitoring information and inspection of mitigation measures. Health impacts to the public may occur during normal operations at generic existing LWR sites via inhalation of air containing hazardous chemicals released to the atmosphere by site operations. Risks to public health from other

Table 3.12.9–3. Doses to Workers From Normal Operation at the Generic Existing Light Water Reactor Site in 1993 (Committed Effective Dose Equivalent)

Occupational Personnel	Onsite Releases and Direct Radiation	
	Standard[a]	Actual
Average worker (mrem)	ALARA	114 to 322
Maximally exposed worker (mrem)	5,000	2,000 to 3,000
Total workers[b] (person-rem)	ALARA	396 to 854

[a] NRC's goal is to maintain radiological exposure as low as reasonably achievable.

[b] The number of badged workers in 1993 ranged from 2,650 to 4,370.

Source: 10 CFR 20; NRC 1995b.

possible pathways, such as ingestion of contaminated drinking water or direct exposure, are low relative to the inhalation pathway.

A discussion of ambient air quality is included in Section 3.12.3. As stated in that section, air quality is expected to be are in compliance with applicable standards. Information about estimating health impacts from hazardous chemicals is presented in Section M.3.

Exposure pathways for generic existing LWR site workers during normal operation may include inhaling the workplace atmosphere and direct contact with hazardous materials associated with work assignments. Occupational exposure varies from facility to facility and from worker to worker, and available information is not sufficient to allow a meaningful estimation and summation of these impacts. However, workers are protected from hazards specific to the workplace through appropriate training, protective equipment, monitoring, and management controls. At the generic existing LWR site, workers are also protected by adherence to OSHA and EPA standards that limit workplace atmospheric and drinking water concentrations of potentially hazardous chemicals. Appropriate monitoring that reflects the frequency and amounts of chemicals utilized in the operational processes, ensures that these standards are not exceeded. Worker health conditions at the generic existing LWR site are expected to be substantially better than required by the standards.

Health Effects Studies. Specific locations for the generic existing LWR must be designated before any reviews of epidemiologic studies in the areas can be conducted.

Accident History. Commercial LWR's that utilize uranium fuel have been in operation in the United States for many years. Accident information for these reactors, where applicable, can be found in documentation available from the NRC. Estimates of potential accidents and their consequences can also be found in safety analysis reports and probabilistic risk assessments prepared by the reactor owners and filed with the NRC. There are no domestic commercial reactors that utilize MOX fuel and consequently there is no information available regarding England accident history for MOX fueled reactors.

Emergency Preparedness. The generic existing LWR site has an emergency management program that would be activated in the event of an accident. The programs are compatible with the other Federal, State, and local plans and are thoroughly coordinated with all interested groups. Programs would be modified, if necessary, to accommodate MOX fueled reactor operations.

3.12.10 WASTE MANAGEMENT

Because of the increased disposal costs for LLW, utility companies have undertaken major volume reduction and waste minimization efforts. These efforts include segregation, decontamination, minimizing the exposure of materials and tools to the contaminated environment, and sorting. Compaction, consolidation, and the monitoring of waste streams to reduce the volume of LLW requiring storage and to lessen the exposure of routine equipment to the reactor environment have been the most effective volume reduction strategies. Between 1981 and 1985 there was a 48-percent decrease in LLW volumes from commercial pressurized LWRs. Current industry-wide volume reduction practices include ultra-high pressure compaction of waste drums, incineration of waste oils and resins, mobile thin-film evaporation, waste crystallization, and asphalt solidification of resins and sludges (NRC 1996b:6-40).

Nuclear power plants currently operating typically have waste minimization programs in place to minimize both the volume and cost impact of waste generation. In existing operating plants, a number of the design considerations that affect the plant waste streams are already in place, and improvements in waste management are continually being implemented. Waste minimization steps include more economical use of disposables or elimination of disposables in favor of recyclables. Process improvements aimed at more efficient use of ion exchange resins and reductions of waste streams from the waste processes are being implemented. In general, wastes generated by operating plants have been decreasing in recent years. The amount of waste generation is reported by each utility on a quarterly basis. Table 3.12.10–1 provides a range of waste volumes based on site-specific data from existing representative LWRs.

Spent Nuclear Fuel. After removal from the reactor, spent nuclear fuel is stored in racks in pools to isolate it from the environment and to allow the fuel rods to cool. Current plans call for spent nuclear fuel to be ultimately disposed of in a deep-geological repository. Because of the delay in siting the repository and interim monitored retrievable storage facilities, utility companies have been faced with the rapid filling of their spent fuel pools. The utility companies have been expanding pool storage, building above-ground dry storage, using longer fuel burnup to reduce the amount of spent fuel requiring interim storage, and shipping the spent nuclear fuel to other plants (NRC 1996b:6-70). When moved to another location, spent nuclear fuel is shipped in casks that are designed to withstand severe transportation accidents and are resistant to small-arms fire and HE detonations (NRC 1996b:6-34).

The average number of spent nuclear fuel assemblies discharged ranges from 64 to 88 for the 8 PWR and 187 to 191 for the 4 BWR existing plants used in the analysis. Licensed spent fuel pool storage capacity (number of assemblies) ranges from 756 to 1,542 for the 8 PWR plants, and 2,040 to 4,020 for the 4 BWR plants.

High-Level Waste. The generic existing LWR would not generate or manage HLW.

Transuranic Waste. The generic existing LWR would not generate or manage TRU waste.

Low-Level Waste. Liquid LLW generated in pressurized LWRs could be classified as either clean waste, dirty waste, turbine building floor drain water, or steam generator blowdown. Clean wastes come from equipment leaks and drains, certain valve and pump seal leakoffs not collected in the reactor coolant drain tank, and other aerated leakage sources. Primary coolant is also considered a clean waste. Liquid wastes collected in the containment building sump, auxiliary building sumps and drains, laboratory drains, sample station drains, and other miscellaneous floor drains are termed dirty wastes because of their moderate conductivity. Clean and dirty wastes will have variable radioactivity content. Detergent wastes, which consist of laundry wastes and personnel and equipment decontamination wastes, normally have a low radioactivity content. Turbine building floor drain water usually exhibits high conductivity with low radionuclide content. Depending on the amount of primary-to-secondary leakage, steam generator blowdown could have relatively high concentrations of radionuclides. The chemical and radionuclide content of the waste would determine the type and degree of treatment before

Table 3.12.10–1. Existing Light Water Reactor Site Waste Management Characteristics

Characteristic	BWR Range	BWR Average	PWR Range	PWR Average	All Plants Average	All Plants Low	All Plants High
LLW shipped (m^3/yr)	367.21 to 936.25	572.61	57.04 to 636.85	178.22	309.69	57.04	936.25
Number LLW shipments/year	39.50 to 108.25	62.84	6.00 to 31.00	16.17	31.73	6.00	108.25
Stored mixed waste/ 1000 MWe (m^3/yr)	Not reported	Not reported	Not reported	Not reported	101.90	Not reported	Not reported
Licensed spent fuel pool storage capacity (number of assemblies)	2,040 to 4,020	3,176	756 to 1,542	1,214	1,868	756	4,020
Average number of assemblies discharged	187 to 191	190	64 to 88	72	111	64	191

Source: ORNL 1995b.

storage for reuse or discharge to the environment. Operating plants have steadily increased the degree of processing, storing, and recycling of liquid radioactive waste (NRC 1996b:2-5).

Solid LLW is generated by the removal of radionuclides from the liquid radioactive waste streams, the filtration of airborne gaseous emissions, and the removal of contaminated material from various reactor areas. The concentrated liquids, filter sludges, waste oils, and other liquid sources are segregated by type, flushed to storage tanks, stabilized for packaging in a solid form by dewatering, and slurried into 0.2 m^3 (0.3 yd^3) steel drums. Other solid LLW consists of spent HEPA filters and wastes from plant modifications and routine maintenance activities such as contaminated protective clothing, paper, rags, glassware, compactible and noncompactible trash, and non-fuel irradiated reactor components and equipment. Tools and other material exposed to the reactor environment would also be considered solid LLW. Compactible solid LLW is taken to an offsite or onsite volume reduction facility before disposal. Solid LLW is stored in shielded prefabricated steel buildings or other facilities until suitable for disposal at an approved LLW disposal facility (NRC 1991a:2-15).

Low-level waste from BWRs primarily consists of concentrated waste from the reactor water cleanup and condensate demineralizer systems and waste generated during maintenance activities (for example, protective clothing, replaced equipment, and so forth). The average annual (1988 to 1992) volume of LLW shipped from a typical BWR unit ranges from 367 to 936 m^3/yr (480 to 1,224 yd^3/yr). The average annual (1988 to 1992) volume of LLW shipped from a typical PWR unit ranges from 57 to 637 m^3/yr (75 to 833 yd^3/yr). For 1993 and 1994, the per-unit volume of waste for all domestic BWRs has fallen to less than 200 m^3/yr, 18 percent under the 1995 industry goal of 245 m^3/yr. The average number of LLW shipments/year from a typical BWR unit ranges from 40 to 108. The average number of LLW shipments/year from a typical PWR unit ranges from 6 to 31. For 1993 and 1994, the per-unit volume of waste for all domestic PWRs has fallen to less than 50 m^3/yr (65.4 yd^3/yr), 45 percent under the 1995 industry goal of 110 m^3/yr (144 yd^3/yr) (ORNL 1995b:B-8).

Mixed Low-Level Waste. Mixed waste generated by a nuclear power plant covers a broad spectrum of waste types. The vast majority of mixed waste in storage at nuclear plants is chlorinated fluorocarbons and waste oil. Mixed LLW is stored onsite until treatment and disposal is available at an offsite RCRA-permitted facility. Because of the occupational exposure from testing radioactive wastes to determine if they are chemically hazardous, the utilities have been looking at ways to eliminate, or at least minimize, the generation of mixed wastes. These efforts include removing and separating hazardous constituents from radioactive streams by remote methods; minimizing the use of solvents exposed to the reactor environment; relying on substitute processes; and recycling and reusing cleaning materials, resins, and waste oils (NRC 1996b:6-66). Stored mixed LLW/1,000 MWe averages 102 m^3/yr (133 yd^3/yr) for all 12 existing plants studied.

Hazardous Waste. Hazardous wastes are generated from nonradioactive materials such as wipes contaminated with oils, lubricants, and cleaning solvents that are used outside the reactor environment. Hazardous wastes are packaged and shipped to offsite RCRA-permitted treatment and disposal facilities.

Nonhazardous Waste. Nonhazardous wastes include boiler blowdown, water treatment wastes, boiler metal cleaning wastes, floor and yard drain wastes, stormwater runoff, and sewage wastes. Depending on the design of the individual reactor, other small volumes of wastewater are released from other plant systems or combined with the cooling water discharges. Sanitary wastes that cannot be processed by onsite waste treatment systems are collected by independent contractors and trucked to offsite treatment facilities (NRC 1996b:6-86).